

**THE LUNAR MAPPING AND MODELING PROJECT.** S. K. Noble<sup>1,2</sup>, R. A. French<sup>1</sup>, M. E. Nall<sup>1</sup>, and K. G. Muery<sup>1</sup>, <sup>1</sup>NASA Marshall Space Flight Center, Huntsville AL 35805, sarah.k.noble@nasa.gov, <sup>2</sup>University of Alabama Huntsville, Huntsville AL 35805.

**Introduction:** The Lunar Mapping and Modeling Project (LMMP) has been created to manage the development of a suite of lunar mapping and modeling products that support the Constellation Program (CxP) and other lunar exploration activities, including the planning, design, development, test and operations associated with lunar sortie missions, crewed and robotic operations on the surface, and the establishment of a lunar outpost. The information provided through LMMP will assist CxP in: planning tasks in the areas of landing site evaluation and selection, design and placement of landers and other stationary assets, design of rovers and other mobile assets, developing terrain-relative navigation (TRN) capabilities, and assessment and planning of science traverses.

**Project Scope and Purpose:** LMMP will provide access to this data through a single intuitive and easy to use NASA portal that transparently accesses appropriately sanctioned portions of the widely dispersed and distributed collections of lunar data, products and tools. Two visualization systems are being developed, a web-based system called Lunar Mapper, and a desktop client, ILIADS, which will be downloadable from the LMMP portal.

We are working closely with the LRO team to prevent duplication of efforts and to ensure the highest quality data products. While Constellation is our primary customer, LMMP is striving to be as useful as possible to the lunar science community, the lunar commercial community, the lunar education and public outreach (E/PO) community, and anyone else interested in accessing or utilizing lunar data.

**Data Sources:** The LMMP will focus predominantly on data products resulting from the Lunar Reconnaissance Orbiter (LRO) and Lunar CRater Observation and Sensing Satellite (LCROSS) missions, but will also utilize historical lunar data (e.g., Apollo, Lunar Orbiter, Clementine, Lunar Prospector) and international lunar mission data (e.g., Kaguya, Chandrayaan-1, SMART-1), as available and appropriate, to meet specific near-term product, product type and/or product resolution and accuracy needs.

**Data products:** LMMP will produce products on a global, regional, and local scale. Local products will be focused on the Constellation program's 50 sites of interest [1]. LMMP will incorporate three different types of products. "Pass-through" products are those which LMMP will ingest and display "as is" from PDS or other sources. Examples of pass through products

include the LOLA topography and Clementine and Prospector derived products. In some cases we will modify the data given to us. Examples of modifications include mosaicking the LROC WAC basemap and georeferencing local images. There are also some products that LMMP is producing. Examples of LMMP products include regional and local DEMs from Apollo and LROC NAC imagery, maps of slope and surface roughness, and maps of crater and boulder distributions.

**LMMP team members and roles:** The project draws on expertise from several NASA and non-NASA organizations (MSFC, ARC, GSFC, JPL, ASU, CRREL – US Army Cold Regions Research and Engineering Laboratory, and the USGS).

The team is well integrated but the major responsibilities are divided as follows:

- MSFC – Management and overall coordination
- Ames - Regional Apollo visible base imagery mosaics and DEMs, EPO web-based neogeography interfaces
- USGS - Local/site visible base imagery mosaics, regional/polar visible base imagery mosaics, local/site DEMs
- JPL - Visualization system infrastructure, web portal and interoperable GIS infrastructure, local/site DEMs (stereo photoclinometry), local/site albedo maps, resource maps, hazard assessment maps
- AZ State U – Local/site DEMs
- CRREL - Web-based visualization system digital overlay tools (Lunar Mapper)
- GSFC - Desktop visualization client – Integrated Lunar Information Architecture for Decision Support (ILIADS)

**Schedule:** The LMMP project passed formulation review in April of 2009 and a level 3 requirements review in June. Following a series of individual product process validation audits and a preliminary system design audit, a beta version of the portal and visualization systems is expected to be released in late 2009. A version 1 release is planned for early 2011. Our schedule for the release of data products is, however, highly dependent on the timing of acquisition of data from LRO.

**References:** [1] Noble S. K. et al. (2009) The 50 Constellation Priority Sites. Abstracts to the 2009 Lunar Science Forum, Mountain View CA.



# The Lunar Mapping and Modeling Project

Sarah Noble, Raymond French,  
Mark Nall, and Kimberly Muery

NASA Marshall Space Flight Center

# Project Background and Overview

- LMMP was initiated in 2007 to help in making the anticipated results of the LRO spacecraft **useful** and **accessible** to Constellation
- The LMMP is managing and developing a suite of lunar mapping and modeling tools and products that support the Constellation Program (CxP) and other lunar exploration activities
- In addition to the LRO Principal Investigators, relevant activities and expertise that had already been funded by NASA was identified at ARC, CRREL (Army Cold Regions Research & Engineering Laboratory), GSFC, JPL, & USGS
- LMMP is a cost capped, design-to-cost project (Project budget was established prior to obtaining Constellation needs)

# Customers

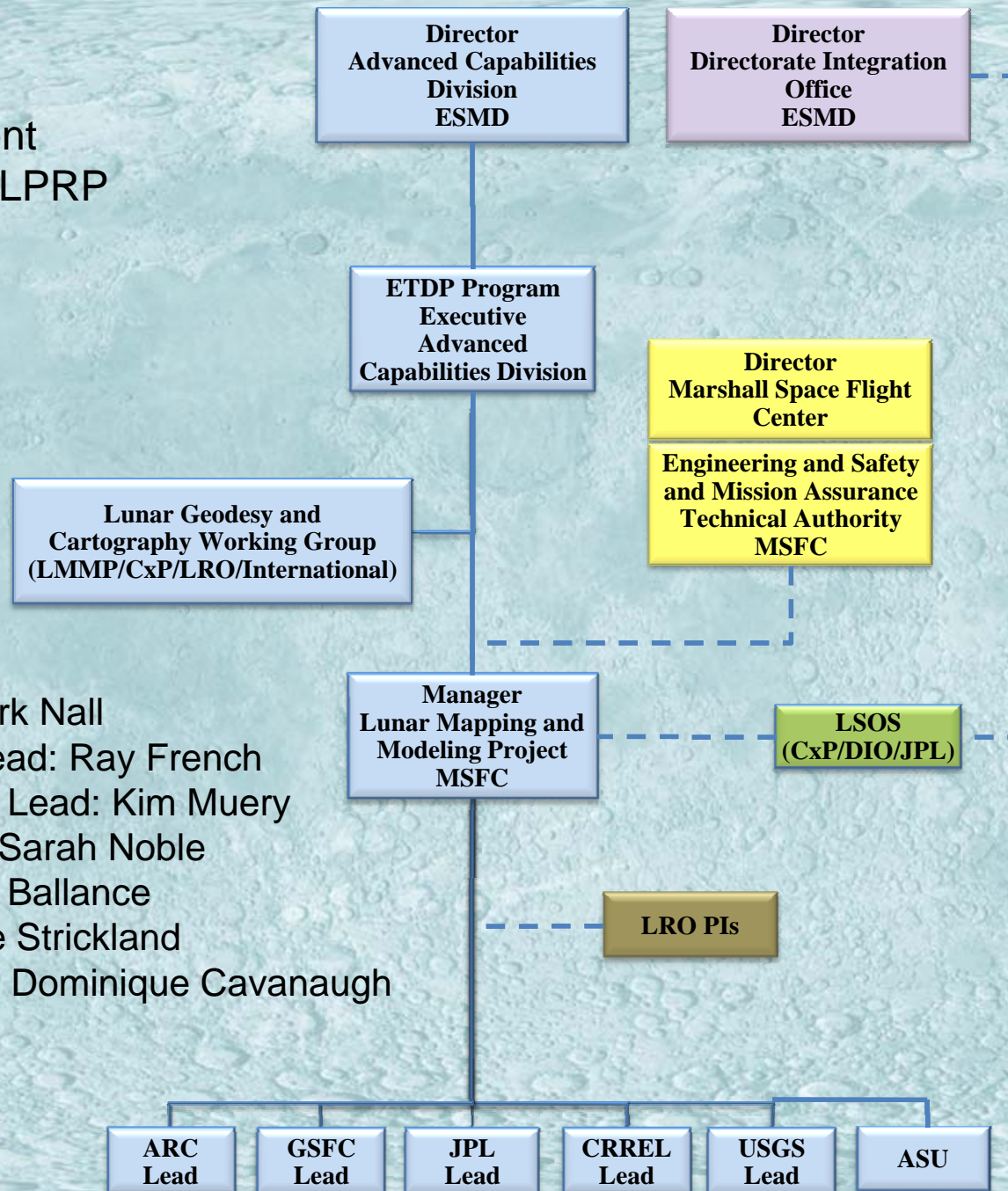
- Main customer is the Constellation program  
The information provided through LMMP will assist them in:
  - planning tasks in the areas of landing site evaluation and selection
  - design and placement of landers and other stationary assets
  - design of rovers and other mobile assets
  - developing terrain-relative navigation (TRN) capabilities
  - assessment and planning of science traverses
- Other customers
  - Science community
  - Commercial community (e.g. GLXP teams)
  - Education/Public Outreach community

Management  
Structure Post LPRP

FY 2010-11

**MSFC Team:**

Project Manager: Mark Nall  
 Project Integration Lead: Ray French  
 Project Development Lead: Kim Muery  
 Project Scientist: Dr. Sarah Noble  
 Chief Engineer: Judy Ballance  
 S&MA TA: Rosalynne Strickland  
 Scheduling and Risk: Dominique Cavanaugh



# LMMP Team

ARC

- Regional Apollo visible base imagery mosaics
- Regional DEMs
- EPO web-based neo-geography interfaces

USGS

- Local/site visible base imagery mosaics
- Regional/polar visible base imagery mosaics
- Local/site DEMs

JPL

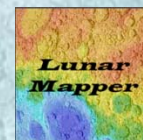
- Visualization system infrastructure, web portal and interoperable GIS infrastructure
- Local/site DEMs (stereo photoclinometry)
- Local/site albedo maps
- Hazard assessment maps (including slope maps)

ASU

- Local/site DEMs

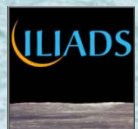
CRREL

- Web-based visualization system digital overlay tools



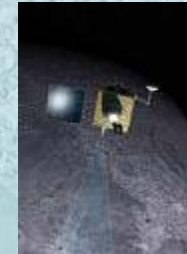
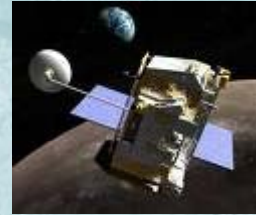
GSFC

- Desktop visualization client – Integrated Lunar Information Architecture for Decision Support



# Data Sources

- LRO
- M3
- Kaguya (gravity model)
- Apollo (metric & panoramic cameras)
- Clementine
- Prospector



# Data Products

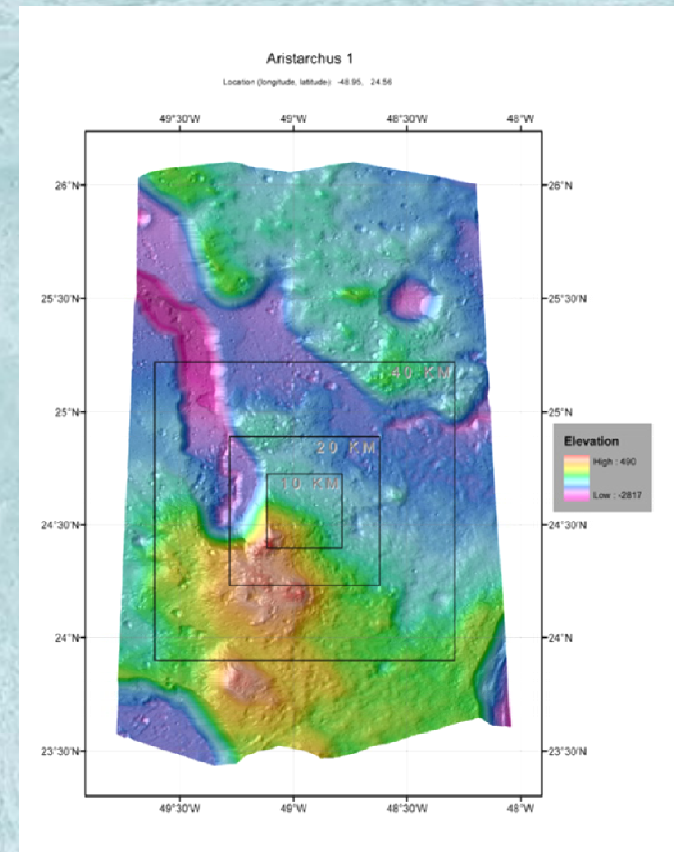
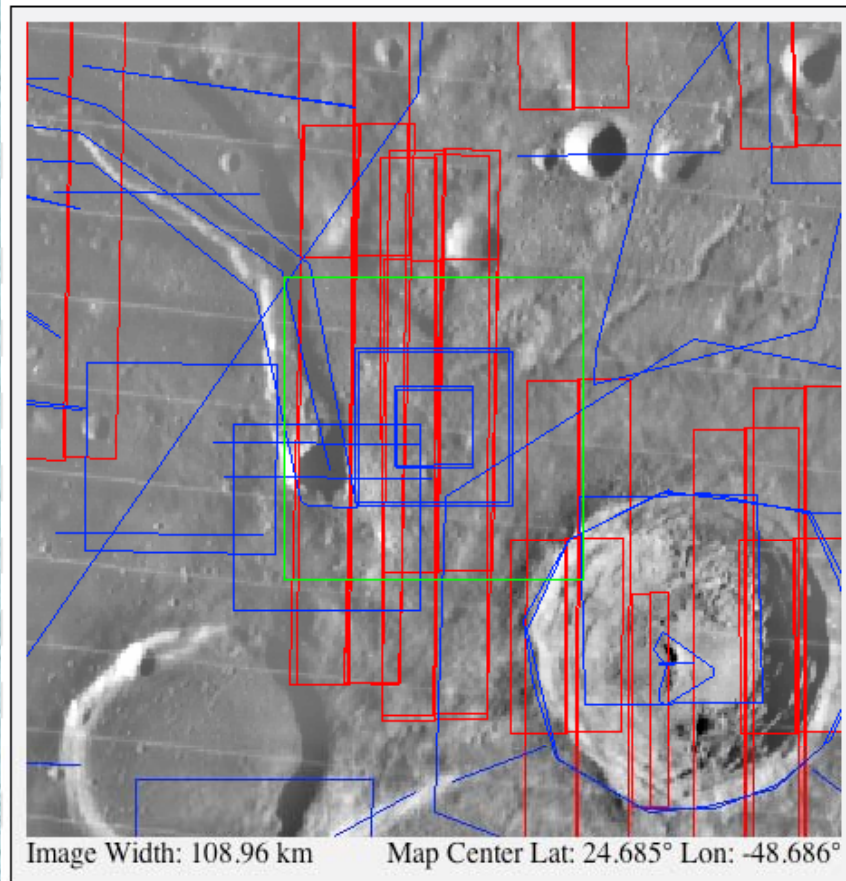
- “Passthrough”
  - e.g. LOLA DEM, Clementine, Prospector, gravity model, lighting model
- Modify
  - e.g. mosaicking basemap, georeferencing local images
- Create...





# DEMs

Local DEMs from LOLA NAC covering the 50 CxP regions of interest

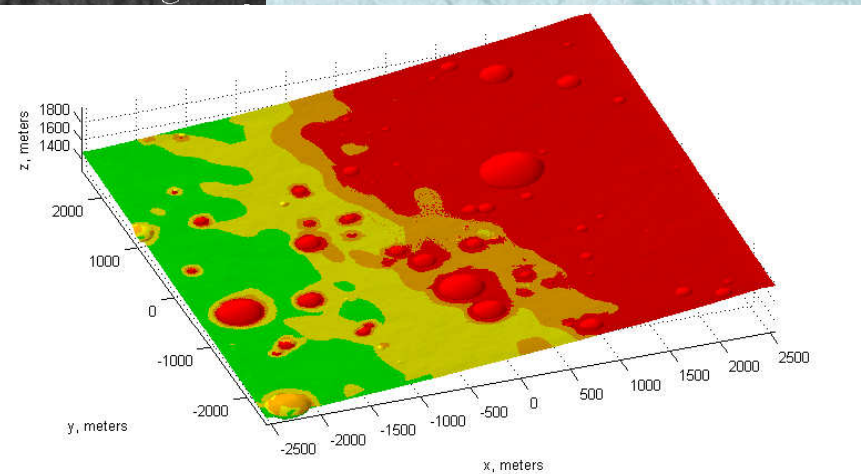
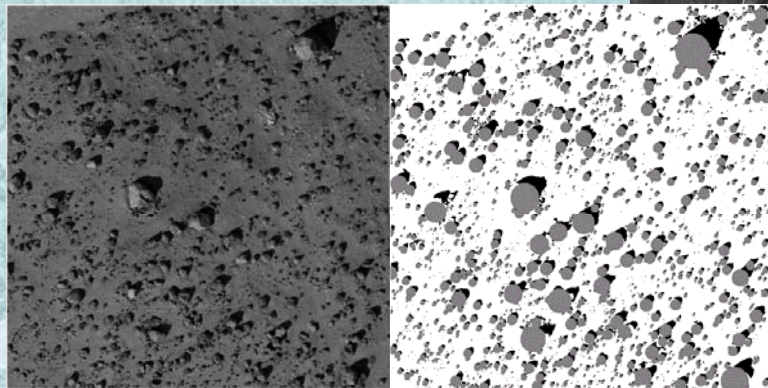
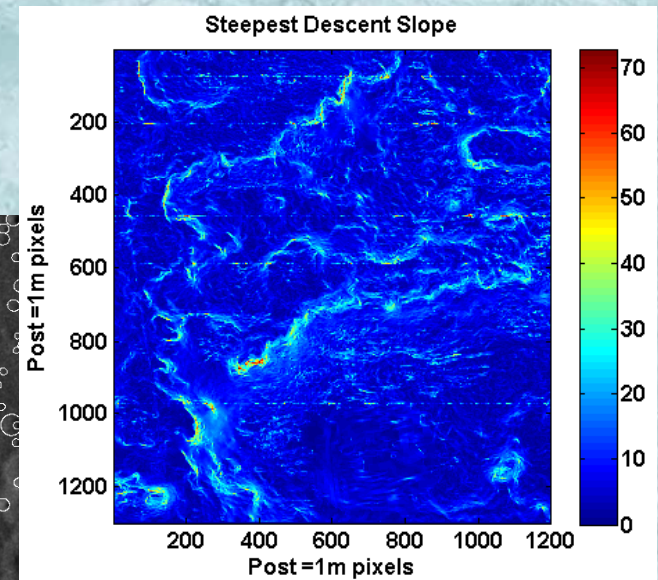
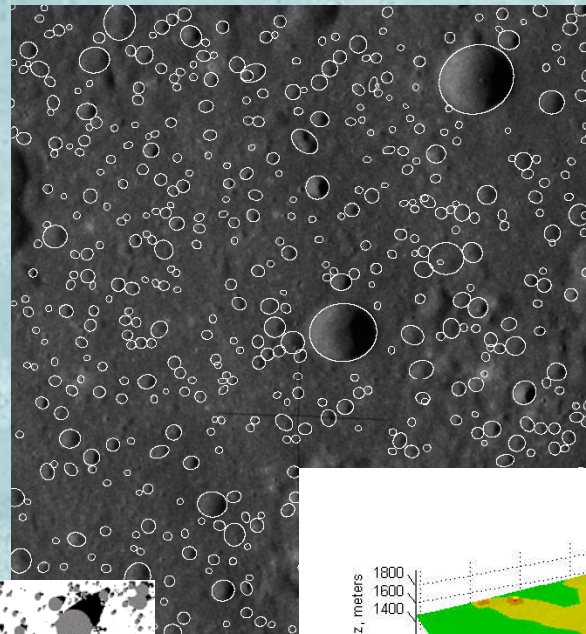


Preliminary USGS Aristarchus Plateau (DEM 1) from JSC/ASU Apollo Pan Cam Scans

Aristarchus 1 ROI showing in red the NAC images acquired through the 1<sup>st</sup> month of mapping orbit

# Created Products - Hazard Maps

- Craters
- Boulders
- Slopes
- Surface Roughness



# Data Products Process

Produce preliminary data products

In some cases using Apollo or other historic data

Hold process validation audits

These have occurred

Acquire final data sets from LRO teams.

Adjust methods, if necessary.

Produce final products

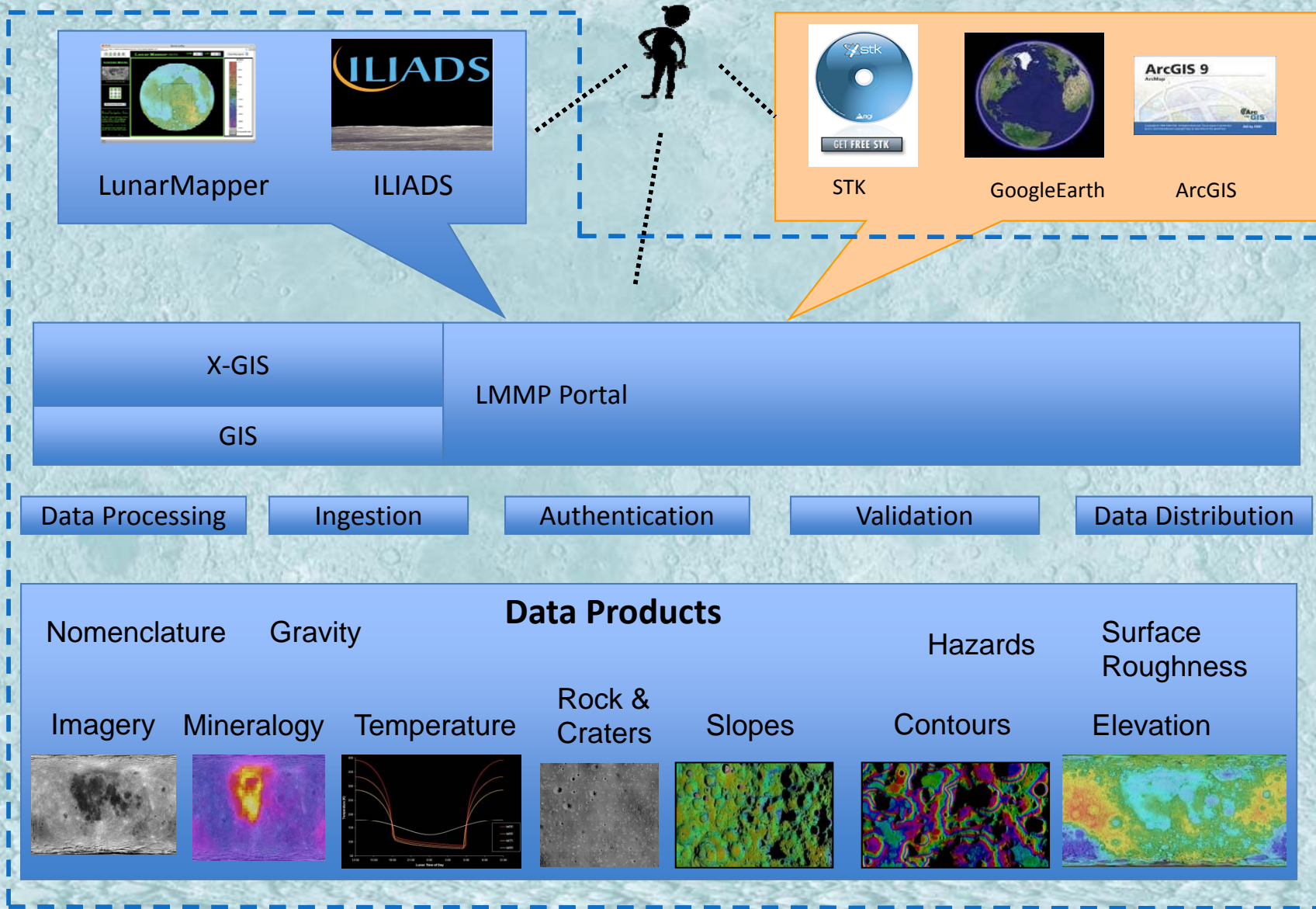
Ingest into LMMP system

Hold final product validation audits

To insure that products are of high quality, display correctly, and meet CxP's needs

Release to Public (or where appropriate, CxP internal use)

# LMMP System



# Portal



HOME

BROWSE

TOOLS

Logout Sarah K Noble



**Info** [X]

Latitude : 17.099250°  
Longitude : 61.367091°

**Distance**

**Maps** [X]

Base Maps    **Layers**

ULCN 2005 DEM

**LO**

LO3

**Lunar Prospector**

Potassium

Thorium

**Search** [X]

**General**    Nomenclat...    Rocks

Search Value

Extent

N.   
W.     E.   
S.

**Search**    **Clear Results**    **Results**

# Lunar Mapper (pre-beta)

**Global Mode**

Longitude: 30 E Latitude: 0

Preview Map Display: Server Base Image

**METERS**

8200  
6000  
4000  
2000  
0  
-2000  
-4000  
-6000  
-8000  
-9900

No topo data

**Lunar Mapper (Beta 0.6g) Preview Map**

illius Caesar  
Lamont  
Mare Tranquillitatis  
DeLainbre  
Hypatia  
Torricelli R  
Taylor  
Zoller  
Gaidorta  
Gutenberg  
Kant D  
Theophilus  
Daguerre  
Gutenberg C Goc  
Cyrillus  
Magelli

**Image Server**  
Backup Server

**Base Image**  
Shaded Relief

center-Lon : 30  
center-Lat : 0  
delta-Lat : 30

**Overlay Layer**  
Local Labels

**Layer Opacity**  
50 %

Lunar Mapper in Global Mode

# Lunar Mapper (pre-beta)

**Search Mode**

Mare Tranquillitatis : Craters 160+ km :  
Mons / Montes : Craters 125+ km :  
Rima : Craters 107+ km :  
Rimae : Craters 96+ km :  
Dorsa / Dorsum : Craters 90+ km :  
Other Features :  
Manmade Objects :

← ○ →  
Slow Spin :

Reference Map

-LON -51.1 29.2 -LAT

**Lunar Mapper (Beta 0.6g) Preview Map**

Rainer T  
Maraldi D  
Plinius  
Illus Caesar  
Lamont  
Delambre  
Hypatia  
Mare Tranquillitatis

Image Server  
Backup Server :  
Base Image  
Shaded Relief :

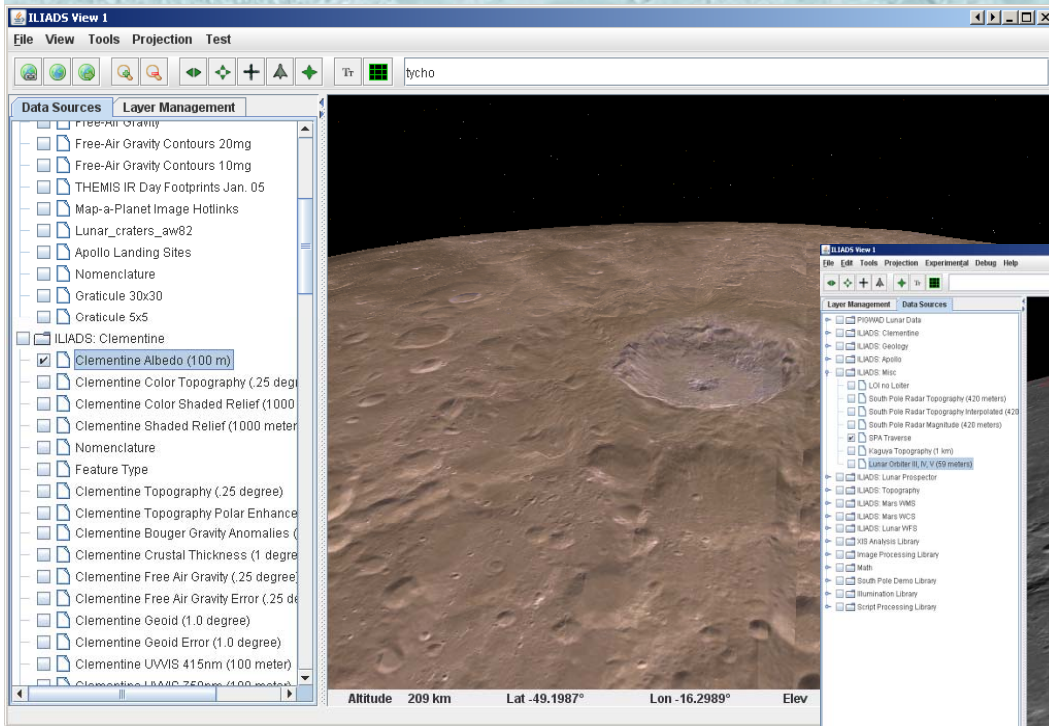
center-Lon : 30  
center-Lat : 9  
delta-Lat : 30

Overlay Layer  
Local Labels :  
Layer Opacity  
50% :

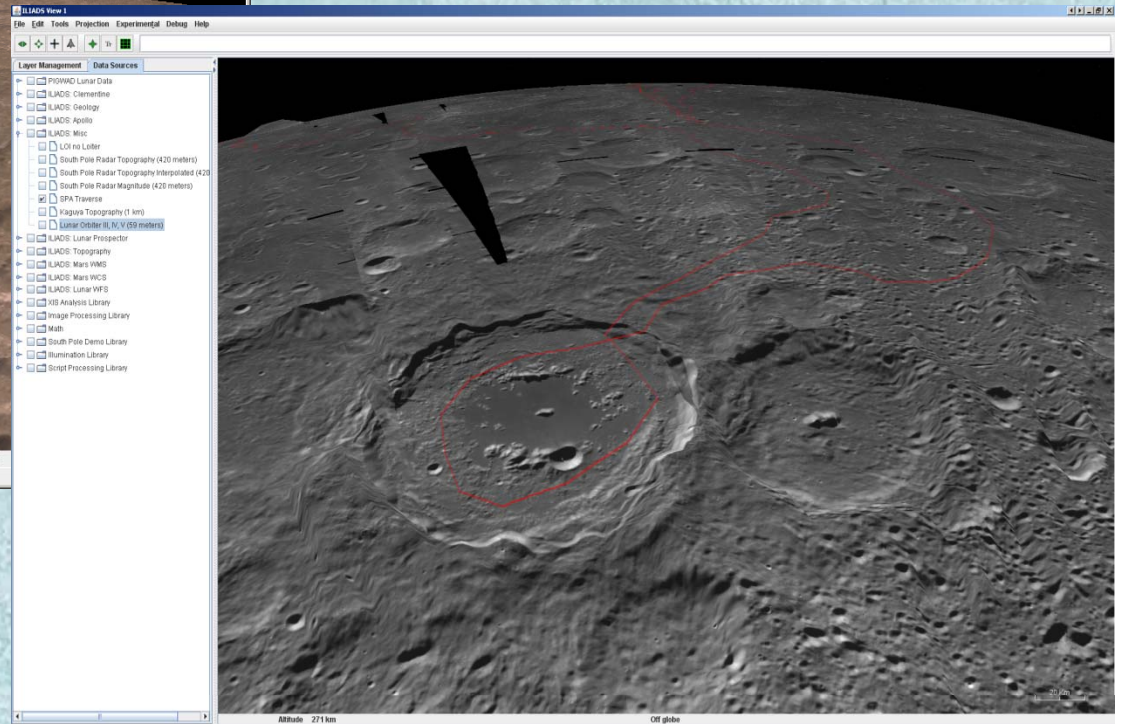
Lunar Mapper in Search Mode



# Integrated Lunar Information Architecture for Decision Support (ILIADS) (pre-beta)

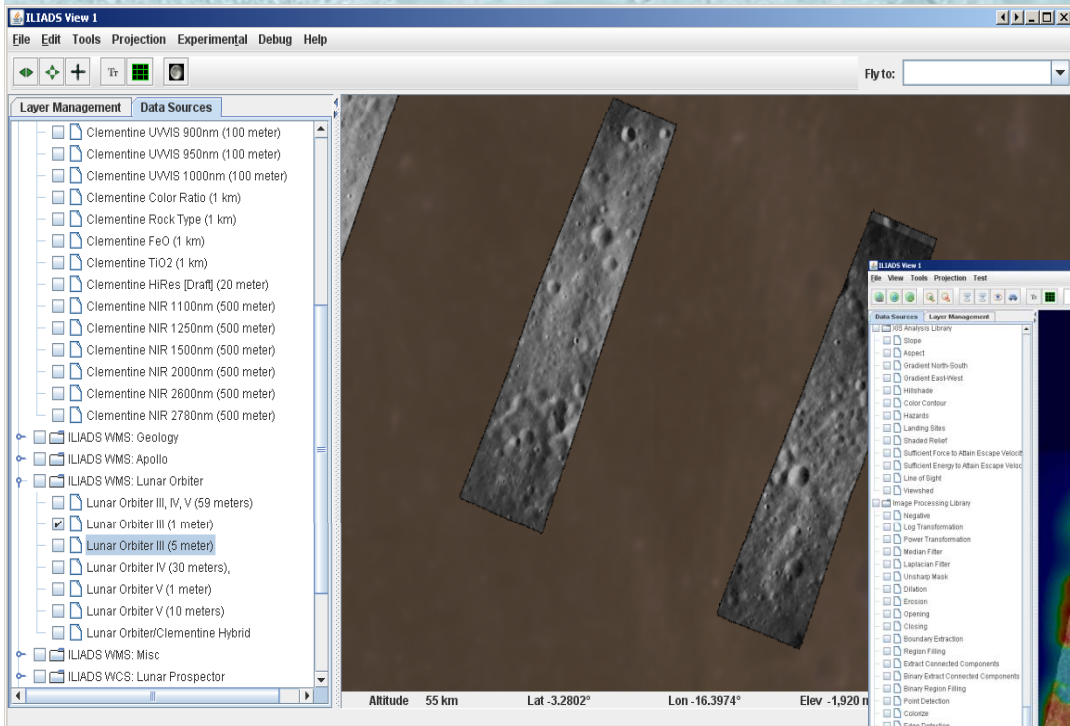


Clementine Albedo (oblique view)

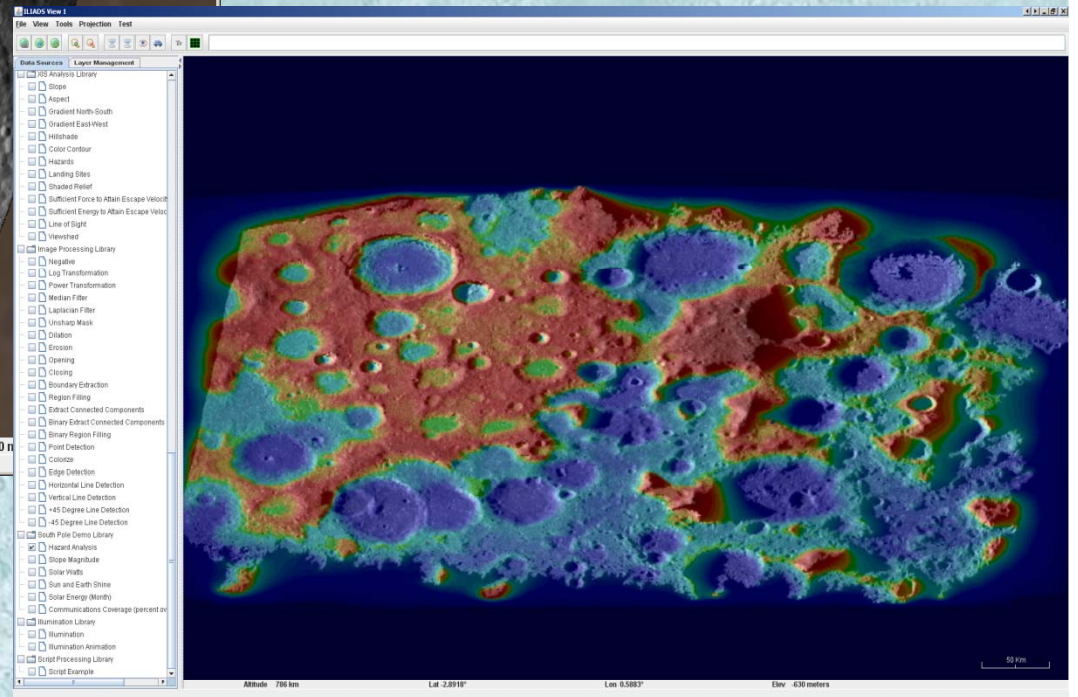


Lunar Surface Traverse Tool (oblique view)

# Integrated Lunar Information Architecture for Decision Support (ILIADS) (pre-beta)



Clementine with high-res Lunar Orbiter



South Pole hazard analysis (surface roughness)

# LMMP Milestones

- Apr 2009 – Formulation review
- Jun 2009 – LRO launched!
- Jun 2009 – Requirements review
- Aug-Sep 2009 – Individual product process validation audits
- Sep 2009 – Preliminary System design audit
- Dec 2009 – Beta release of Mapper, ILIADS, Portal, infrastructure and content
- Late 2010/Early 2011 – Version 1 release